

A SYSTEMATIC LITERATURE REVIEW ON FORECASTING MALAYSIA'S CRUDE PALM OIL PRICE BY CONSIDERING STORAGE COST USING GEOMETRIC BROWNIAN MOTION

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ABSTRACT

Recent research has shown a growing interest in exploring Malaysia's crude palm oil (CPO) price forecasting, with a particular focus on integrating storage costs using the Geometric Brownian Motion approach. This study undertakes a thorough Systematic Literature Review (SLR) adhering to the PRISMA model. The primary objective is to systematically identify, assess, and consolidate relevant literature that investigates the prediction of Malaysia's crude palm oil price, considering the impact of storage costs through the application of the Geometric Brownian Motion method. To ensure the review's credibility, specific criteria were established for data selection. The search encompassed well-known search engines like Google Scholar, ERIC, Scopus, ResearchGate, and other reputable databases to retrieve pertinent research papers for inclusion in the SLR. By comprehensively analysing relevant studies, the review seeks to uncover research patterns and valuable insights concerning the interplay between storage costs and CPO price forecasting. Both statistical and mathematical methods have been used among past researchers to forecast commodity prices. However, there is no article that did forecast CPO prices or other commodities by considering the storage cost factor. Hence, the resulting findings are expected to offer essential guidance for future research and informed decision-making within the palm oil industry.

Keywords: Crude Palm Oil, Geometric Brownian Motion, Storage Cost, Systematic Literature Review.

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1. Introduction

Crude palm oil (CPO) is a significant contributor to the Malaysian economy. According to Isa et al. (2020), Malaysia has now surpassed Indonesia as the world's second-largest producer and exporter of palm oil. CPO is widely used as an edible oil globally due to its adaptability and relatively low production cost. The management of commodity price risk has been a longstanding concern for both consumers and producers, and the role of storage in mitigating such risks is acknowledged by Cafiero et al. (2011a). Secomandi (2010) emphasises that commodity prices are highly variable and volatile. Utilising storage between production and consumption can help buffer against price volatility. Regardless of the availability of risk transfer options, storage remains a crucial process. Without risk transfer mechanisms, the



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price of seasonal commodities could potentially be higher before peak production periods, contrasting with the current situation (Black, 1976a).

This research paper aims to perform a systematic literature review (SLR) centred on predicting the price of crude palm oil (CPO) in Malaysia. The primary objectives are to comprehensively assess, analyse, and categorise the available literature pertaining to this topic. Through this process, the study intends to uncover prevalent research patterns, main research objectives, targeted demographics, methodologies employed, and the types of data utilised in various research studies. Throughout the review, Table 1 will present the primary themes to be investigated in relation to the issue of forecasting CPO prices.

Table 1: Themes of this study.

No.	Themes
1.	Purpose of the study
2.	Targeted population
3.	Methodology
4.	Data used

2. Literature Review

Palm oil holds the distinction of being the largest vegetable oil traded globally (Mungmee et al., 2013). The cultivation of oil palm in Malaysia has witnessed remarkable expansion over the years. According to Nambiappan (2018), the planted area started with a modest 55,000 hectares in 1960 and underwent significant growth, reaching 193,000 hectares by 1970. Crude palm oil (CPO) is a crucial feedstock for producing biofuel, particularly biodiesel. The utilisation of biodiesel derived from palm oil brings various advantages, including enhanced energy security, reduced dependence on non-renewable energy sources, and lower greenhouse gas emissions compared to fossil fuels. The demand for CPO has been steadily increasing, leading to an average price rise in Malaysia from £2,456 per MT in 2009 to £3,620 per MT in the subsequent year (BT Zainal, 2013). Conversely, the cost of commodity storage assumes a significant role in numerous economic sectors, particularly those reliant on commodity production, distribution, and consumption.

Carter & Giha (2007) provided empirical evidence that storage under backwardation is an economic occurrence that can take place within a single market and for the same grade of commodity. Storage models play a pivotal role in diverse industries and sectors, assisting in optimising supply chain processes by determining the most suitable location, capacity, and design for storage facilities. As highlighted by Secomandi (2010), commodity prices are well-known for their variability and volatility. Storage assets offer managers a practical option to purchase commodities at specific times, store them, and subsequently sell them to capitalise on price variability and volatility. It is essential to acknowledge that CPO prices can be unpredictable and subject to change. Traders, investors, and business stakeholders closely monitor these factors, along with other market indicators, to predict price fluctuations and make well-informed decisions.

3. Research Methodology

This research employs the Systematic Literature Review (SLR) technique with the main objective of identification, screening, eligibility, and combining multiple studies related to the prediction of Malaysia's Crude Palm Oil price while considering storage costs using

Geometric Brownian Motion. The study follows the recommended reporting materials for systematic reviews and meta-analysis (PRISMA) as proposed by Peter et al. (2019), which involves distinct steps, namely Identification, screening, adequacy, and insertion. The methodology used to address this research topic is presented in Figure 1.

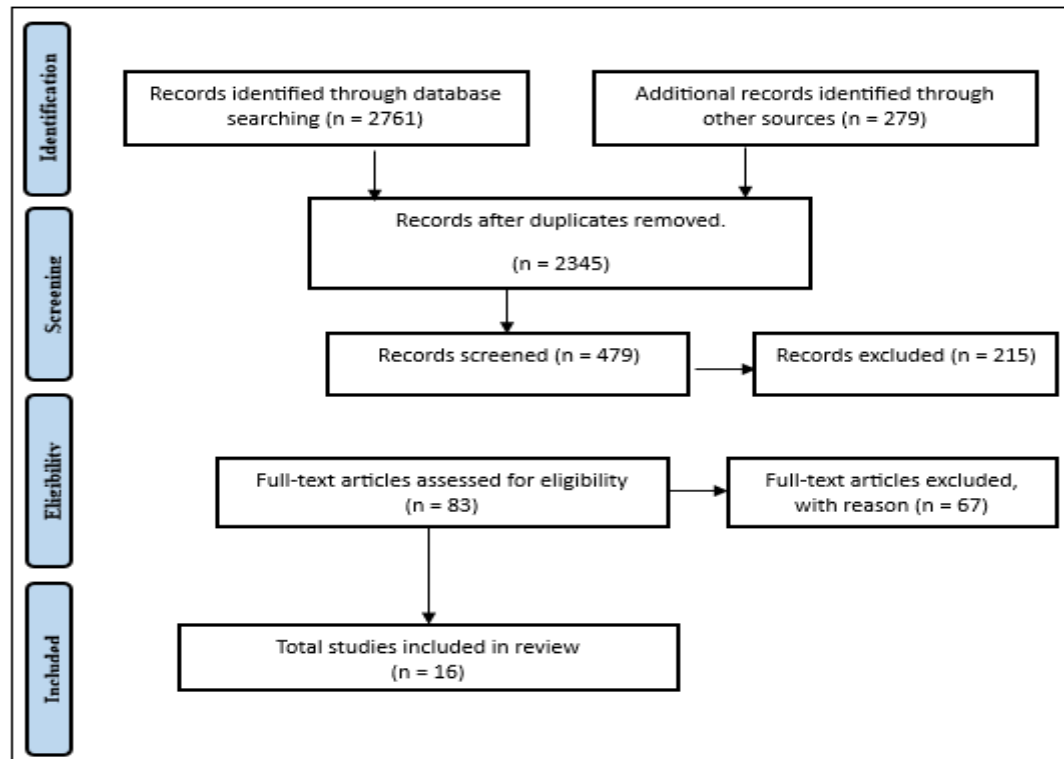


Figure 1. Research Data Search & Selection Flow

Furthermore, the data analysis resulted in the examination of 16 articles based on their relevance, as depicted in the chart. Table 2 offers a summary of the descriptions of these articles. In summary, this Systematic Literature Review aims to comprehensively analyze existing research on the forecasting of Malaysia's Crude Palm Oil price by incorporating storage costs using Geometric Brownian Motion. It meticulously follows the PRISMA guidelines to ensure a robust and reliable review process.

Table 2(a): Identification of the articles for further analysis.

No.	Article Title	Year	Author's Name	Journal Name
1.	Palm oil: Addressing issues and towards sustainable development.	2009	Tan, K. T., Lee, K. T., Mohamed, A.R., & Bhatia, S	Renewable and Sustainable Energy Reviews
2.	Crude palm oil price fluctuation in Malaysia.	2020	Isa, M. A., Baharim, A. T., Mohamed, S., Noh, M. K., Nasrul, F., Ibrahim, W. M., & Hassan, S. S.	International Journal of Academic Research in Business and Social Sciences

Table 2(b): Identification of the articles for further analysis.

No.	Article Title	Year	Author's Name	Journal Name
3.	Impact of crude palm oil on engine performance, emission product, deposit formation, and lubricating oil degradation of low-speed diesel engine: An experimental study.	2023	Cahyo, N., Sitanggang, R.B., Simareme, A. A., & Paryanto, P.	Journal of Results in Engineering
4.	The challenges of a biodiesel implementation program in Malaysia.	2020	Zulqarnain, Yusoff, M. H., Ayoub, M., Jusoh, N., & Abdullah, A. Z.	Journal of Processes
5.	A study on the factors affecting crude palm oil (CPO) price in Malaysia.	2013	BT Zainal, Balqis. N.	SSRN Electronic Journal
6.	A framework study of factors affecting crude palm oil price behavior in Thailand.	2013	Mungmee, T., Buaklom, P., Pungprasert, P., Sinlapaprechar, P., Suksa-ard, C., & Raweewan, M.	Proceedings of the 2013 (4th) International Conference on Engineering, Project, and Production Management.
7.	Theory of storage and the pricing of commodity claims.	2004	Nielsen, M. J., & Schwartz, E. S	Review of Derivatives Research
8.	The empirical relevance of the competitive storage model.	2011	Cafiero, C., Bobenrieth H., E. S. A., Bobenrieth H., J. R. A., & Wright, B. D	Journal of Econometrics
9.	Modeling commodity salam contract between two parties for discrete and continuous time series.	2017	Hisham, A. F., & Jaffar, M. M.	AIP Conference Proceedings.

Table 2(c): Identification of the articles for further analysis.

No.	Article Title	Year	Author's Name	Journal Name
10.	Crude palm oil price forecasting in Malaysia: An econometric approach.	2018	Khalid, N., Warwan, N. F., Thinagar, S., & Hamidi, H. A.	Journal of Economic Malaysia.
11.	Forecasting on crude palm oil prices using artificial intelligence approaches.	2013	Karia, A. A., Bujang, I., & Ahmad, I	American Journal of Operations Research.
12.	Comparison between Artificial Neural Network and ARIMA model in forecasting palm oil price in Malaysia.	2021	Wei Yee. K, B.S. Humaida,	International Journal of Scientific Engineering and Science
13.	Progress Accuracy of CPO price prediction: Evidence from ARMA family and artificial neural network approach.	2011	Karia A.A, Bujang. I	International Research Journal of Finance and Economics
14.	Brownian motion and its application in the stock market.	2005	Angeliki Ermogenous	Department of Applied Mathematics, Illinois Institute of Technology, Chicago, IL, 60616, USA.
15.	Forecasting share prices of small-size companies in Bursa Malaysia using geometric Brownian motion.	2014	Abidin, S. N., & Jaffar, M. M.	Applied Mathematics & Information Sciences
16.	Forecasting value at risk of the foreign exchange rate by integrating geometric Brownian motion.	2018	Karim, S. N., & Jaffar, M. M.	Communications in Computer and Information Science

From Table 2, most of the articles involved the commodity asset. The range of years for these 16 articles is from the year 2004 to the year 2023. Data collection was carried out to analyse further information in section 4, based on predetermined criteria.

4. Data Collection and Analysis

The research gathered data from various electronic databases, encompassing Google Scholar, Scopus, ResearchGate, and additional sources. The search utilised multiple keywords,

including crude palm oil (CPO), Malaysia's CPO price forecasting, storage cost, and economics. All the selected articles were chosen according to predetermined criteria, based on the SLR model equation, which stands for Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA). The criteria were carefully applied to ensure the inclusion of reputable scientific journal publications. The collected data from these chosen articles is presented in Table 3 as part of this study.

Table 3(a): Data collected from the articles.

No.	Article Title	Purpose of the studies	Targeted Population	Methodology	Data Used
1.	Palm oil: Addressing issues and towards sustainable development.	This study compares palm oil to other vegetable oils including rapeseed and soybean oil to show the potential of palm oil as an acceptable and appealing source of biodiesel.	Power plant operators, engineers, researchers, and decision-makers who are responsible for fuel selection and engine performance optimization.	1) Real scenario analysis.	1) Data by research analysis.
2.	Crude palm oil price fluctuation in Malaysia.	The goal of this study is to investigate the relationships between the effects of four macroeconomic factors on the Malaysian CPO price, namely the exchange rate (EXC), inflation (INF), money supply (M3), and gross domestic product (GDP).	Stakeholders, researchers, academics, palm Oil Growers, and Producers.	1) Augmented Dickey-Fuller test (ADF) unit root. 2) Correlation and multiple regression tests.	1) The CPO secondary data was collected from the World Bank and DataStream.
3.	Impact of crude palm oil on engine performance, emission product, deposit formation, and lubricating oil degradation of	The goal of this study is to evaluate the feasibility of converting the current diesel engine to run on CPO fuel to reduce the need for new	Power plant operators, engineers, researchers, and decision-makers who are responsible for fuel selection and engine	1) Test Phases 2) Performance Evaluation 3) Emission Testing	1) Engine gross power, peak combustion pressure, indicated horsepower (IHP), exhaust temperature, and emissions

	low-speed diesel engine: An experimental study.	capital investments.	performance optimization.		levels.
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Table 3(b): Data collected from the articles.

No.	Article Title	Purpose of the studies	Targeted Population	Methodology	Data Used
4.	The challenges of a biodiesel implementation program in Malaysia.	The article discusses the significance of the B10 blend—10% biodiesel and 90% petroleum diesel—the difficulties associated with the import and export of palm oil throughout the world, and the safeguards needed to ensure the palm oil industry's long-term success.	Agricultural Sector, Stakeholders, Research and Academic Community.	1) Data analysis 2) Testing phase	1) CPO data from MPOB.
5.	A study on the factors affecting crude palm oil (CPO) price in Malaysia.	The major goal of this study is to identify the factors that have the greatest influence on Malaysia's price for crude palm oil (CPO).	Stakeholders, researchers, academics, palm Oil Growers, and Producers.	1) Non-stationary test 2) Multiple linear regression test (t-test, f-test).	1) Independent variable - Price of Soybean Oil - Price of Coconut Oil - Price of Sunflower Oil - Price of Olive Oil 2) Dependent variable - Price of Crude Palm Oil (CPO)

6.	A framework study of factors affecting crude palm oil price behavior in Thailand.	The suggested study's goal is to investigate the variables that influence the cost of crude palm oil (CPO) in Thailand.	Stakeholders, researchers, academics, palm Oil Growers, and Producers.	1) Multiple Linear Regressions analysis.	1) Data from MPOB and CPO prices from Thailand.
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Table 3(c): Data collected from the articles.

No.	Article Title	Purpose of the studies	Targeted Population	Methodology	Data Used
7.	Theory of storage and the pricing of commodity claims.	The goal of this study is to add to the body of knowledge on commodity pricing by including a relationship between spot price volatility and the gap between future prices, which is based on the theory of storage.	Market analysts, economists, traders, investors, policymakers, and researchers.	1) Gibson–Schwartz (1990) model	1) Copper spot and forward price data from 1994 to 2000.
8.	The empirical relevance of the competitive storage model.	This study's main goal is to respond to Deaton and Laroque's main critique of the models of competitive storage arbitrage's capacity to account for the degree of serial correlation shown in commodity prices.	Researchers and economists specializing in commodity markets and price analysis.	1) Econometric approach.	1) Time series of commodity prices (including those for bananas, cocoa, coffee, palm oil, and other goods) from 1900 to 1987.
9.	Modeling commodity Salam contract between two parties for discrete and continuous time series.	The purpose of this study is to propose the development of an Islamic compliance product, specifically an Islamic derivative, to enhance the competitiveness of Islamic finance in comparison to conventional finance.	Islamic financial institutions, academics, practitioners, and regulators comprise the field of Islamic finance.	1) Time Value of Money 2) Cost of Carry Model 3) Geometric Brownian Motion.	1) CPO data from April 2015 until April 2016.

Table 3(d): Data collected from the articles.

No.	Article Title	Purpose of the studies	Targeted Population	Methodology	Data Used
10.	Crude palm oil price forecasting in Malaysia: An econometric approach.	This study compares several economic forecasting methods to predict how the price of crude palm oil (CPO) would behave in Malaysia.	Market analysts, economists, traders, investors, policymakers, and researchers.	1) Autoregressive Distributed Lag (ARDL) 2) Autoregressive Integrated Moving Average with exogenous inputs (ARIMAX) 3) Autoregressive Integrated Moving Average (ARIMA)	1) Monthly time series CPO data spanning from 2008 to 2017.
11.	Forecasting on crude palm oil prices using artificial intelligence approaches.	The goal of the study is to evaluate different forecasting methodologies and decide which one is more appropriate and accurate for projecting CPO prices based on historical data.	Investors, traders, financial analysts, economists, policymakers, and researchers.	1) Artificial neural network (ANN) 2) Adaptive neuro-fuzzy inference system (ANFIS) 3) Autoregressive fractionally integrated moving average (ARFIMA).	1) Daily free-on-board CPO prices in Malaysia from (1/1/2004) to (31/12/2011).
12.	Comparison between Artificial Neural Network and ARIMA model in forecasting palm oil price in Malaysia.	The aim of this study is to anticipate Malaysian palm oil prices using an artificial neural network (ANN) and an autoregressive integrated moving average (ARIMA) model. The two models are compared, and the more precise model is chosen.	Investors, traders, financial analysts, economists, policymakers, and researchers.	1) ANN Model 2) ARIMA Model	1) The price of palm oil monthly from January 2008 to December 2018.



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Table 3(e): Data collected from the articles.

No.	Article Title	Purpose of the studies	Targeted Population	Methodology	Data Used
13.	Progress Accuracy of CPO price prediction: Evidence from ARMA family and artificial neural network approach.	This study's goal is to predict the price of crude palm oil (CPO) using several forecasting methods, particularly the ARMA family and artificial neural network (ANN).	The researchers, practitioners, and professionals in the field of finance, economics, and commodity markets.	1) Artificial neural network (ANN). 2) ARMA family. 3) RMSE and MSE.	1) CPO data from (3/1/2006) to (30/12/2010).
14.	Brownian motion and its application in the stock market.	The purpose of this paper is to introduce Brownian motion, describe its characteristics, and describe how it works in the stock market, a normal yet completely unexpected setting.	The researchers, practitioners, and professionals in the field of finance, particularly those interested in modelling and simulating stock prices.	1) Geometric Brownian motion model 2) Black Scholes Model	1) Proving theorem.
15.	Forecasting share prices of small-size companies in Bursa Malaysia using geometric Brownian motion.	This study's goal is to provide a strategy for predicting tiny firms' closing prices in the future using geometric Brownian motion.	Investors who are interested in making short-term investments in small businesses.	1) Geometric Brownian Motion 2) MAPE	1) Share Prices Data for Mulpha Land Berhad from Bursa Malaysia.
16.	Forecasting value at risk of the foreign exchange rate by integrating geometric Brownian motion.	This study's goal is to concentrate on Malaysia's foreign exchange risk and exchange rate.	Individuals and entities involved in foreign exchange trading and risk management in Malaysia.	1) Geometric Brownian Motion 2) VAR model	1)10 currencies data, which are CNY, SGD, JPY, EUR, USD, THB, KRW, IDR, TWD, and AUD



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5. Result and Discussion

This section further elucidated that the utilisation of the content analysis method enabled the researcher to systematically recognise the characteristics of the content, encompass substantial textual data, and draw sound conclusions from the text. This technique involved four distinct phases for data analysis, which encompassed 5.1 the study's purpose, 5.2 examining the targeted population, 5.3 evaluating the methodology employed, and 5.4 analysing the data used.

5.1 Purpose of the Studies

The purpose of the study phase sets the stage for understanding the research's main objectives and intentions. It provides context for the specific goals and aims that guided the research process.

Table 4: Purpose of the studies from the articles

Analyse compounds in biodiesel	Analyse factors affecting CPO	Analyse storage cost variable	Propose pricing commodity modelling (GBM)	Compare forecasting method on CPO	Forecast using GBM (Other than a commodity)
n = 3	n = 3	n = 2	n = 2	n = 4	n = 2

According to Table 3, most articles are focused on crude palm oil (CPO) as their primary subject. Table 4 provides insights into the objectives of several publications, with a significant portion aiming to examine the variables influencing CPO. Six out of the 16 articles aim to forecast future commodity prices, and four of them specifically concentrate on CPO prices. Interestingly, there are no articles that address the forecast of CPO prices while considering storage costs. This finding highlights the need for further research in this area, specifically focusing on forecasting CPO prices by incorporating storage costs.

5.2 Targeted Population

The targeted population phase lays the foundation for understanding the specific group or demographic under examination in the research. It provides context for why this particular population was chosen and highlights its significance within the broader study.

Table 5: Targeted population in the articles

Researchers and Academics	Palm Oil Producers	Stakeholder	Researcher & Stakeholder	All Included
n = 2	n = 2	n = 2	n = 6	n = 4

Identifying the targeted population is crucial to enhance the effectiveness and efficiency of the study. Table 5 indicates that most papers target researchers as their audience. However, considering the purpose of the study, forecasting CPO pricing could potentially

engage additional stakeholders as a possible targeted group. For instance, when publications discuss palm oil ingredients, the manufacturers of palm oil become a relevant target audience. Consequently, there should be a greater focus on articles directed towards palm producers in the future.

5.3 Methodology

The methodology phase serves as an essential precursor to understanding the approach and techniques employed in the research process. It offers insight into the methods chosen and outlines their relevance in achieving the study's objectives.

Table 6: Method used in the articles.

Case Studies	Forecasting	Data Analysis	Correlation coefficient	Pricing
n = 3	n = 6	n = 3	n = 3	n = 1

Based on Table 6, four out of the six articles focused on forecasting CPO prices utilised the ANN model and the ARIMA model. Meanwhile, the GBM model was employed in two publications for forecasting currency and stock values. Additionally, three papers examined the relationship between CPO and its components using the correlation coefficient. Based on this data, it is evident that further studies should prioritise the application of pricing models to predict CPO prices.

5.4 Data Used in the Articles

The phase focusing on Data Used in the Articles lays the foundation for understanding the sources of information and datasets utilised in the research. It contextualises the choice of particular data sources and underscores their significance in contributing to the study's outcomes.

Table 7: Data used in the articles.

Currencies	Share prices	CPO prices	Other commodities	Others
n = 1	n = 1	n = 9	n = 3	n = 2

Out of the 12 articles that utilised commodities data, eight were centred on CPO data, while the remaining four utilised data on other commodities such as copper, cocoa, coffee, etc. Most of the collected data comprised a series of more than 5 years. The length of the data series is crucial in determining the accuracy of future price predictions, as more data leads to more precise findings. Consequently, there is a need for more articles to concentrate on currencies and share price data in the future.

6. Conclusion

This study constitutes a systematic literature review (SLR) focused on forecasting Malaysia's crude palm oil price, with an emphasis on storage cost. It analyses 16 articles published between 2004 and 2023 in reputable international journals, carefully selected based on predetermined criteria. The study offers a comprehensive overview of the SLR's findings, identifying and categorising research themes while synthesising the results. Four main themes emerged from the data analysis: the study's objectives, targeted population, methodology, and data sources. However, a limitation of this review is the absence of articles forecasting CPO prices using the Geometric Brownian Motion (GBM) model, and the relatively small number of articles reviewed or analysed. Conducting a literature review requires a more extensive scope, encompassing a larger quantity of research and producing more comprehensive review articles. The consideration of storage cost in commodity price forecasting has been lacking, indicating the need for further research in this area. The role of storage cost is crucial in maintaining the demand and supply chain for all commodity prices. Thus, exploring asset pricing models, particularly the GBM model, seems promising for forecasting commodity prices, including CPO.

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9. Conflict of Interest

The authors have no conflicts of interest to declare.

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